IV.—*On Geological Contacts and Ancient Erosion in Southern and Central New Brunswick.*—*By* L. W. BAILEY.

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The importance of geological contacts in the determination of the structure and geological history of different regions is well understood, and in the study of the latter these receive, as they deserve, especial attention. While the various formations, in their petrological characters, their thicknesses, and their contained fossils, afford the data for estimating the conditions of their origin and their relative duration, it is along their lines of junction that we are to look, more than elsewhere, for information as to the circumstances under which they came to a close; in other words, for the time and nature of the physical breaks by which the historical record is divided into its separate chapters, and made comparable with those of other regions.

In the study of the geological structure of the Province of New Brunswick, which, as regards its general features, is now well advanced, a variety of such contacts has been observed and detailed in the geological reports. From the peculiar position, however, which this Province occupies with reference to the great north-eastern or Acadian basin, and from the fact of its possessing a larger number of determinable horizons than any other portion of that basin, of which it therefore becomes to a certain extent the key, the consideration of these contacts has an interest beyond the immediate region in which they are found, and suggests conclusions of much wider application. It is the intention of the writer, in the following remarks, to consider briefly some of the more important of these junctions, and the deductions which they may seem to justify. As the passage from one formation to another is usually accompanied by evidences of more or less extensive erosion, and as this, in some instances, affords almost the only proof of a want of continuity, some observations on this latter point may also prove of interest.

The reference of a portion of the rocks of southern New Brunswick to a pre-Silurian, Azoic, or, as it is now better termed, Archean age, was first asserted by the writer in connection with Mr. G. F. Matthew in 1865, on the ground of their relations to the fossiliferous rocks of St. John, then first identified by Hartt as containing a typically Primordial fauna. It is remarkable that, while the recognition of this ancient horizon is not exceeded, as regards the completeness of the data, by that of any subsequent formation, so its relations to the underlying rocks are of the most satisfactory and conclusive character. For not only do they differ wholly in lithological characters, a feature which some writers suppose to have been the only ground for their separation, but, in every particular ordinarily marking discordance of successive formations, the evidences here offered are wide-spread and complete. Whatever view be taken as to the precise equivalence of the underlying groups which have been compared respectively with the Laurentian and Huronian systems, the fact remains that these represent a vast thickness of sedimentary

strata of the most diverse character, and that, while at one point the Primordial rests upon what appear to be the most recent of these strata, at another it reposes upon beds which cannot be less than several thousands of feet lower in the series, while the conglomerates which mark its base bear further testimony, both in their composition and their thickness, to the erosive processes which preceded or accompanied the deposition of the Primordial sediments. Finally, while local unconformable contacts may be seen at many points, an equally marked discordance is observable in the two groups as a whole, the trends of the Primordial being transverse to those of the supposed Huronian, as the folds and dislocations of the one are quite independent of those of the other. The Lower Silurian, or Cambrian, formation is thus as clearly defined in its stratigraphical relations as it is in its paleontological features, and forms a readily recognizable horizon, with reference to which the position of both older and more recent groups may be directly compared.

As regards the older systems to which reference has been made, New Brunswick has been naturally looked to as likely to afford some information upon the questions which have recently awakened so much attention, regarding the number and order of succession of the pre-Cambrian rocks, and has, indeed, been frequently referred to in discussions of this subject. It can, however, I think, hardly be said that these questions, as here applied, have yet received a definite solution. That there are among the rocks referred to three, if not four, distinct groups of strata, exhibiting strong lithological contrasts, and probably representing entirely distinct periods and conditions of deposition, was early recognized and has been confirmed by all later study of the region, but the precise relations in which these stand to each other and their correlations with proposed subdivisions of Archean rocks elsewhere, are not so easily settled and have been variously regarded by different observers. Thus, while the writer, in common with Mr. G. F. Matthew, by whom the structure of the district was first studied, has described, in what he believes to be an ascending succession, a gneissic, a calcareous, a felspathic, and a schistose group,—the two former being regarded as representing the Laurentian and one at least of the latter the Huronian system,—Dr. Hunt has been disposed to question the existence of true Laurentian in this district, and to modify the above arrangement by associating the calcareous with the schistose group, regarding both as newer than Huronian and equivalents of what he has elsewhere termed Montalban. Without attempting to deny that such an arrangement is possible, and that, if sustained by further investigation, it would bring the succession in this region into remarkable parallelism with that observed elsewhere, the writer, after long and repeated study of the region, is still constrained to think that the facts of the case are such as to favour the former rather than the latter view of the actual structure. Thus, applying the test of contacts, which it is the purpose of the present paper more particularly to consider, it is not a little remarkable that while the calcareo-silicious group may be seen at many points resting upon, and in direct contact with, the coarser gneisses, following these throughout their distribution, and apparently involved in the movements by which they have been affected; nothing at all resembling the strata first named is to be found in connection with the schistose group, where the few limestones which are met with are very impure, of insignificant thickness, of different character, and of wholly unlike associations. Again, if the calcareous and associated strata are really more recent than the felsite-petrosilex group, the entire absence of the latter between the same calcareous beds and the underlying gneisses, when these are observed together,

would imply an amount of erosion which, considering the nature of the material composing the felsitic group and the vast bulk which it exhibits even at a very limited distance, seems altogether improbable. It may be added that while pebbles, derived alike from the felsitic and schistose beds, occur abundantly and in great variety in the basal conglomerates of the Primordial, no such pebbles from either member of the calcareous group have been identified in such a position as they naturally would be in, were the latter group immediately subjacent. All that can at present be positively asserted is: (1) the super-position of the limestone-quartzite series upon the granitoid gneiss, though perhaps distinct from the latter, and (2) the interposition of a vast body of schistose strata, quite unlike those of the first named group, between the felsitic rocks and the basal beds of the Primordial. It may be added that between the felsitic group and the overlying schists and conglomerates the contacts are abundant and easily observed, showing not only distinct unconformity of dip, but at least a partial breaking up of the lower beds, accompanied by the extensive extravasation of igneous rocks and the formation of coarse tuffs and agglomerates, filled with blocks derived from the horizons beneath. Adopting this view of the succession, it will be found to accord very nearly with that described by Dr. Hicks and others as characterizing the district of St. David's in Wales, where fossiliferous Cambrian strata, containing a fauna similar to that of St. John, are in like manner underlaid in downward succession by slaty and comparatively little altered rocks (Pebidian), a middle group (Arvonian), comprising contemporaneous volcanic rocks, felsites, breccias and tuffs, and having a thickness of 15,000 feet, and a lower group (Dimetian) consisting of granitoid and quartzose rocks with coarse gneiss and bands of limestone and dolomite. The Coastal, Coldbrook and Portland groups of the New Brunswick local reports present apparently identical features both of origin and arrangement. We may now pass to the consideration of some more recent horizons.

In connection with the Primordial or Cambrian rocks of St. John, no remains of younger formations are to be met with, except it be those of the Lower Carboniferous series, and although in the more northerly belt of such rocks, found in the valley of the St. John River in King's County, these are approached somewhat nearly by fossiliferous beds of Upper Silurian age, no actual contact of the two has been observed. It is, however, to be remarked that while beneath the Primordial rocks of this region there are, as in St. John County, felspathic and schistose beds, succeeding in turn a well defined felsite-petrosilex group, the latter is also directly and unconformably covered by the Upper Silurian strata, thus indicating the extensive erosion to which the surface had been subjected prior to the deposition of these later sediments,—a circumstance made still more conspicuous by the occurrence of numerous hills, some of them several hundred feet in height, which rise like islands through the nearly horizontal Upper Silurian beds, being evidently fragments of a formation at one time much more widely distributed. The nature of these beds and the fossils they contain show that the waters in which they were deposited were but of moderate depth.

It has long been known that rocks of Upper Silurian age are widely spread over the northern counties of New Brunswick, and that these are bordered along their southern edge by wide belts of much harder rock, flanking one or more belts of granite, and in the vicinity of the latter often presenting the aspect of highly crystalline schists, this second group being variously described by Gesner, Robb, Hitchcock, Hind and others as Silurian, Cam-

brian, Mica-schist group and Quebec group. Until within the last year or two, however, no definite knowledge existed, either as to the true limits or relations of these several sets of rocks, or even whether in the lower group there might not really be included several distinct formations. In 1879, the base of the Upper Silurian in that part of Carleton County lying east of the St. John River was approximately fixed by Mr. Matthew, and, simultaneously but independently, a like boundary was determined by myself between the town of Woodstock and the Maine frontier. More recently both of these districts have been reexamined and the line of contact of these formations carefully studied for a distance of not less than thirty miles. Though somewhat obscured by overlying carboniferous sediments, the unconformity of the two is, nevertheless, strongly marked: first, in the occurrence at the base of the upper series of thick beds of calcareous conglomerate filled with fragments (black silicious slate and petrosilex) derived from the group below; secondly, in a difference both of strike and dip; and thirdly, as a result of this difference, in the progressive overlapping of the newer formation upon the several members of the older. The fossils of the later group are numerous and varied, and indicate an horizon corresponding either to that of the Niagara or Lower Helderberg; in the lower are a few shells and graptolites, together with fragments of trilobites, apparently of the genera *Trinucleus* and *Harpes*, but too poorly preserved to be certainly determinable.

The relations of these supposed Cambro-Silurian rocks to the granite open up numerous questions, as interesting as they are difficult. They present, indeed, only another phase of the well-known Taconic controversy, so admirably summarized and discussed by our distinguished Vice-President in the lately issued volume of our Transactions. Into the broader questions involved in this controversy it is not necessary, nor do I feel prepared, to enter; the objects of the present paper will be sufficiently served by presenting a few facts of actual observation in the field, with such conclusions as are of direct local application. In the case of both of the great granite belts which traverse New Brunswick, the contacts of the latter with the bordering stratified rocks are best seen along their northern edge, from which overlying material has been for the most part removed, while it has been extensively accumulated along that of the south. Where thus exposed it invariably presents the following features:—

1. The transition from massive, compact and uniform granite to the associated schists or other rocks is instantaneous and abrupt.

2. The invaded beds vary greatly in character, embracing coarse and fine gneisses, mica schists, chloritic and hornblendic schists and fine micaceous sandstones.

3. Foliation and crystallization are most marked in the vicinity of the granite, and decrease in receding from the latter, but vary greatly in the apparent distance to which the effect has extended, this being in some instances only a few yards, while in others it is several miles.

4. The outline of the granite is irregular, and, while in part parallel to the strike of the enclosing schists, at others it intersects these obliquely or even at right angles, or sends into the latter irregular tongues.

5. Detached masses or bosses, of various forms and sizes, border the main granitic areas, indicating, beneath the schists, a wide-spread and uneven granitic floor.

6. Granitic veins, not different from the main mass of the granite, but readily distin-

guishable from true segregated veins which accompany them, penetrate the schists in all directions to a distance of several hundred feet.

7. Large detached blocks, of various sizes up to two or three feet, but usually angular and sometimes rectangular, are enclosed in the granite, and produce the appearance of a coarse granitic breccia.

To the above it may be added that small patches, sometimes not more than a few yards or feet in extent, of gneissic or schistose rock, are occasionally met with resting upon, but inseparable from, the granite, at very considerable distances from the nearest exposures of such schistose rock, while smaller masses, which are evidently detached fragments, occur in all parts of the granite area, often retaining the same features of texture, foliation, and even of colour, presented by the main body of such rocks.

From a consideration of the above and other facts, the conclusion seems to be fairly established that the granites in question are intrusive or exotic, and that the alteration of the associated rocks was an accompaniment, if not an effect, of such intrusion. It may be added that while the several belts of slates and schists, north and south of, or central to, the granite, have been variously described as wholly or partly of different age or origin, recent minute examinations of the region show beyond question their essential identity,—the same crystalline and semi-crystalline rocks always appearing where the granite is approached, whether from the southern, northern or eastern side, while in the opposite directions these as invariably graduate into the upper and comparatively unaltered argillites and greywackes. At what period the extravasation of the granite occurred is less certain. As far as yet observed in Carleton County, no veins of the latter are to be found penetrating the Upper Silurian, although veins of syenite and diorite are common; but the fact observed in the southern counties, that the conglomerates older than the Lower Carboniferous are destitute of granitic pebbles, while those of the latter formation abound with them, taken in connection with the evident similarity of the granites in the two regions, and the precisely similar effects accompanying them, appears to indicate that both are of synchronous origin and both Devonian. In either case the amount of erosion which has since occurred is sufficiently indicated by the facts already stated, the whole granitic area, with a superficies of several hundred square miles, having been evidently laid bare by the denudation of beds (schists, slates and sandstones,) which, though now miles apart, were at one time continuous over it, and which, to judge from their highly inclined attitude and vast thickness, must have buried it to a very considerable depth. The fact that the granite areas are usually lower than those of the bordering schists would also seem to indicate that erosion has been more extensive and complete along these areas than in the regions adjacent to the latter; while the much greater breadth of the region of metamorphism and foliation on the northern side of the granite, than on the southern, would appear to indicate a much more abrupt descent in the junction line of the granitic mass on this latter side than upon the opposite. It is to the contrasts thus produced that the different views, which have been advanced by different observers as to the relations of the strata in the district, are to be ascribed.

I pass now to the contacts of the Devonian. In the southern counties the rocks of this age, so far as they have been certainly identified, are of very limited distribution, and rest only upon rocks of Cambrian or pre-Cambrian age, a portion of these latter, by an overturn and fault, being also brought to rest, in a position of comparative conformity,

upon the Devonian strata, and thus originating a misconception which for some years obscured the true structure of the region. No contacts of Devonian and Silurian are to be found in this part of the Province; and though such contact has been supposed to occur in connection with the argillites bordering the central coal-field, the age and relations of these rocks can hardly be regarded as definitely settled.

In rising to the Lower Carboniferous, we reach an horizon and a series of contacts which, whether they be regarded simply in themselves, or in their accompaniments of erosion and lithological contrasts, constitute the most marked boundary line in the physical history of New Brunswick. Resting indifferently and unconformably upon all the older formations (Laurentian, Huronian, Cambrian, Upper Silurian, Devonian and granite); composed of material, in some instances fossiliferous, derived from all these formations, and varying in its aspect with the nature of the rock on which it rests; exhibiting no sign of those metamorphic influences which have hardened, crystallized, or debitumenized all the older beds beneath, even to the Devonian, but, on the contrary, being even in its lowest portions saturated with petroleum and containing deposits of Albertite,—the study of this formation, from whatever point of view, suggests conclusions of the greatest interest. So marked and so wide-spread are the contrasts referred to, not in New Brunswick only but everywhere around and over the Acadian basin, and so important were the movements by which these contrasts were determined, that we may well style the epoch in which they occurred the Acadian or Devonian revolution. It was, indeed, probably at this time that the Acadian basin proper first became clearly outlined by the elevation of its bordering hills, and when all the more marked of those physical features which now distinguish it became determined. It is remarkable that both the breadth of the formation and its elevation above the sea-level progressively increase in passing from the western to the eastern side of the Province, beds of this age in the former being rarely met with more than two or three hundred feet above the sea, and mostly confined to the valleys, while in the opposite direction they gradually mount the sides of the hills, and, in the case of Shepody Mountain, in Albert, cap the latter at a height of twelve hundred feet. There is, however, good reason to believe that they formerly spread over much wider areas and possessed a considerably greater thickness than they now exhibit. Thus, not only on Shepody Mountain, but on other portions of the southern hills, at scarcely inferior elevations, strata of this age may be observed in positions which are not far from horizontal, and which appear to be merely the detached and isolated fragments of a formation, which at one time must have been continuous, and which deeply buried the entire region in which they are found. So again, similar rocks, showing similar evidences of marine origin, are found in scattered areas over portions of York, Carleton and Victoria Counties, which are also but little inclined, and which have probably been disconnected by erosion. Some of these in the Beccaquimic region cannot well be less than 800 or 900 feet above the sea-level. In King's County the peculiar topography of such localities as the Dutch valley and Upham, are evidently due to the removal of extensive masses of this formation by denuding processes.

Still further evidence of the extent to which this formation has suffered by removal is shown in its relations to the overlying coal-measures, and brings us to consider another line of contact, of special interest as bearing upon the important question of the coal-producing capacity of this formation. There can be no question that, at many points, the

red calcareous beds of the Lower Carboniferous pass up into those of the millstone-grit, not only without unconformity, but with direct evidence of transition between the two; as for example about Hillsborough in Albert County, where the denudation which has taken place would appear to have occurred at a later period: but on the other hand there are also evidences that this conformity is in many instances only apparent, resulting from the fact that both sets of beds are approximately horizontal, and that a considerable interval, involving a large amount of corrosion and deformation of the surface, occurred prior to the deposition of the later strata. Thus, while in the Grand Lake district we have, on the Newcastle River, a regular and apparently conformable succession of Lower Carboniferous marine sediments, millstone-grit, and productive coal-measures, all with only a very low inclination; borings through these latter at a distance of only a few miles, and on the side of the dipping strata, resulted in showing the entire absence of the lower beds, while at yet another point, on Coal Creek, the coal-measure rocks may be seen, for miles, resting upon uplifted pre-Carboniferous slates, without the intervention of the Lower Carboniferous. So also, in some parts of York County, points almost within sight of each other show horizontal coal-measure rocks resting at one time upon nearly vertical Lower Silurian beds and at another upon an apparently thick mass of Lower Carboniferous sediments. The wide-spread accumulations of dolerite, basalt and amygdaloid, which intervene between the summit of the last-named group and the millstone grit, may be regarded as further evidence of their unconformity. The supposition of conformity in beds so nearly horizontal would necessarily imply, with wide superficial extent, a very limited thickness to the coal-formation; while that last mentioned, by supposing the deposition of these beds upon a surface extensively folded and eroded, will at least admit of the possibility of a very varied thickness of the coal strata, and consequently of the occurrence of other seams of coal than those now known and worked near the surface.

The last contact to which it is necessary here to refer is that of the Carboniferous formation with the Trias or new red-sandstone. Several examples of such contacts have been observed along the southern coast, but, apart from the fact of placing beyond question the existence here of Mesozoic deposits, they present no features of special interest.

In recapitulation, it will appear from the foregoing observations that we have in New Brunswick not less than six well defined physical breaks, with all the usual accompaniments of unconformity, viz., one between the Primordial and pre-Cambrian, four between the several subdivisions of the Paleozoic, and one between the latter and the Mesozoic, to which may be added certainly two, and probably three, similar breaks among the pre-Cambrian rocks. In each of these cases, excepting perhaps that between the two main divisions of the Carboniferous, the unconformability is accompanied and in part indicated by the formation of heavy beds of conglomerate, while, in most instances, the same lines of junction are marked by the occurrence of eruptive rocks, the result probably of the same forces to which the unconformity is to be ascribed. In the case of the Devonian revolution, involving movements of the entire Paleozoic series, there were, in addition to the eruptions of trap, the extensive extravasations of granite which constitute so marked a feature in the geology of Acadia, and which have had so profound an influence on all its subsequent history.